3.4.1 Springs

	Learning outcomes		Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)		tensile and compressive deformation; extension and compression	
(b)		Hooke's law	
(c)		force constant *k* of a spring or wire; *F* = *kx*	
(d)	**(i)**	force–extension (or compression) graphs for springs and wires	*M3.2*
	(ii)	techniques and procedures used to investigate force–extension characteristics for arrangements which may include springs, rubber bands, polythene strips.	**PAG2** HSW5, 6

3.4.2 Mechanical properties of matter

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	force–extension (or compression) graph; work done is area under graph	*M3.1*
(b)	elastic potential energy; $E = \frac{1}{2}Fx$; $E = \frac{1}{2}kx^2$	*M0.5, M3.12*

(6) M - State and describe types of deformation
(7) S - Draw force extension curves for a spring, rubber band and polythene
(8) C - Explain techniques to investigate force extension characteristics for springs rubber bangs and polythene

Lesson 2. Deformation

0:05:00

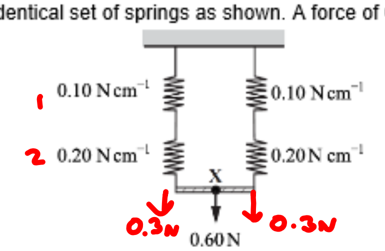
S
A

STARTER:

A spring with force constant 0.10 N cm^{-1} is placed in series with one of 0.20 N cm^{-1}. These are then placed in parallel with an identical set of springs as shown. A force of 0.60 N is applied.

$F \propto x$

$F = kx$



What distance does the point **X** move down when the 0.60 N force is applied?

A. 2.0 cm

$x_1 = \frac{F}{k_1} = \frac{0.3}{0.1} =$

B. 3.0 cm

$x_2 = \frac{F}{k_2} = \frac{0.3}{0.2} =$ +

C

C. 4.5 cm

D. 9.0 cm

Your answer

[1]

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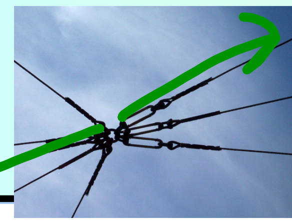
ACTIVITY 1: Explain why a pair of forces in needed to deform an object. What are the two **arrangements** of these force pairs?



HWK:

Key point

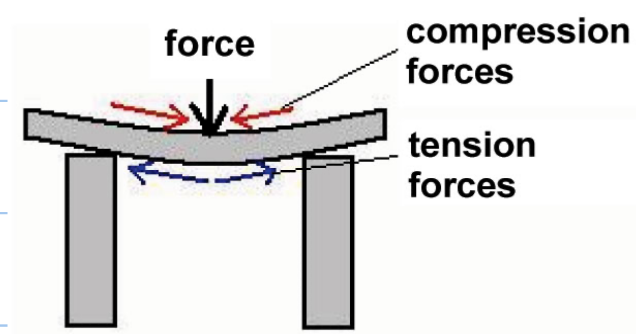
Tensile and compressive forces.

You need a pair of equal and opposite forces to change the shape or **deform** an object. There are two types of force that deform an object:

Forces that produce **extension** are **tensile** forces

Forces that produce **compression** are **compressive forces.**

Ex: You walk across decking and it bends. It that **compressive** or **tensile** forces? Explain.



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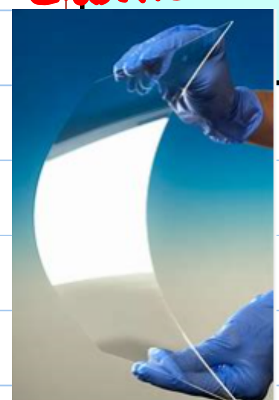
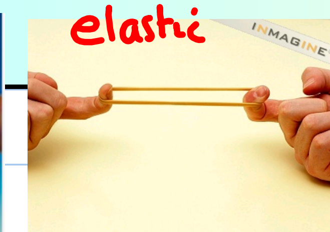
ACTIVITY 1: Material themselves can deform in 3 ways....

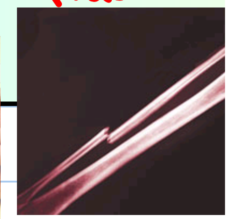
elasitic

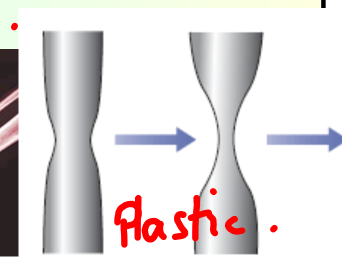


elastic



brittle fracture.





necking leading to fractu

Plastic

Plastic.

Materials can deform in three ways:

Elastic deformation: Will return to original dimensions once deforming force is removed

Plastic deformation: Permanent change to the dimensions after a deforming force is removed.

Brittle fracture:Breaks sharply without plastic deformation

Ex: Can you think of an examples of 2 type of deformation occurring together?

(6) M - State and describe types of deformation
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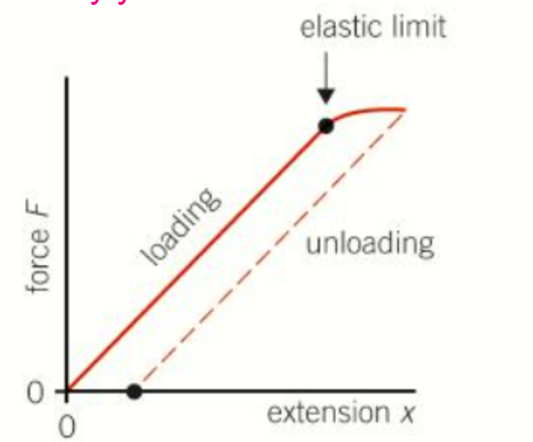
0:05:00

Key point

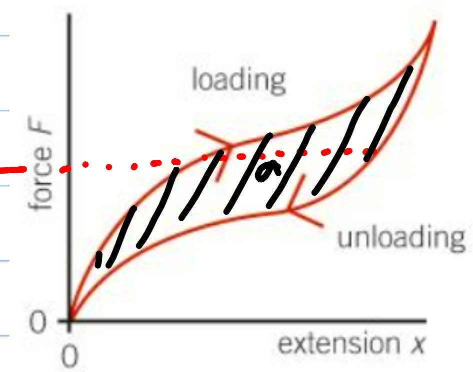
What **materials** could these loading curves represent ?

What type of deformation is happening in each?
Justify your answer.



don't demo

Spring or wire.



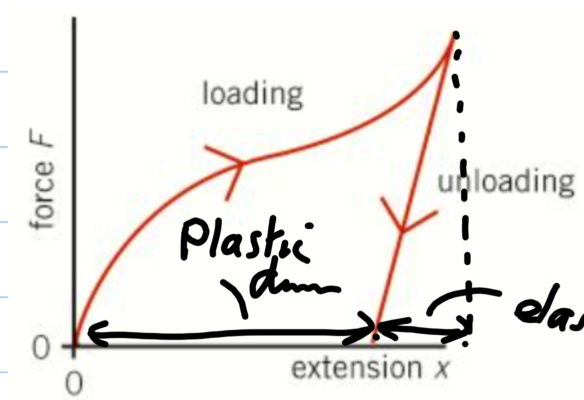
don't demo

Rubber

link to aircraft.

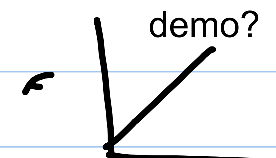
area under graph = work done

area a = Thermal energy lost by loading and unloading.



elastic deformation

demo?



bone.

Polythene bag / Chewing gum.

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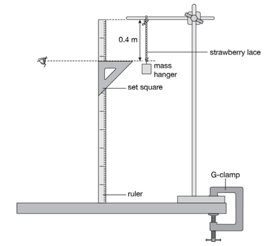
0:05:00

ACTIVITY 1: Strawberry laces practical



Kilo 10^3

Mega 10^6 **Ex 1** - How does this activity link to the space topic

Giga 10^9 **Ex 2** - How does this activity link to the space topic


Key point

Use Excel to plot.

Sketch the graph

Questions

1 Which of these words best describes the behaviour of a strawberry lace and why? *(2 marks)*

Hard   Ductile   Brittle

2 Does a strawberry lace obey Hooke's law? *(2 marks)*

3 The strawberry laces demonstrate a phenomenon known as creep. What do you think that is and how did you take it into account when recording the new length of the lace? *(2 marks)*

4 Using your observations and results identify the point on your graph at which the strawberry lace began to deform plastically. Explain your choice. *(2 marks)*

Answers for method sheet

1 Ductile. *(1 mark)*
The strawberry laces deform plastically and are drawn into longer laces before breaking. *(1 mark)*

2 Laces do not obey Hooke's law. *(1 mark)*
The force is not directly proportional to the extension. *(1 mark)*

3 Creep is the phenomenon where the lace continues to extend after the load is added. *(1 mark)*
Students can either:

- use initial readings *(1 mark)*
- wait a set period of time before taking them. *(1 mark)*

Both methods are equally valid.

4 Look at their results table – from experience the laces do not return to their original length when the load is removed very early on in the loading. *(1 mark)*
So they should identify a point early in their graph. *(1 mark)*

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Plenary

0:05:00

State the meaning of *elastic* and *plastic* behaviour.

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.... **[1]**

Repeatedly stretching and releasing rubber warms it up.
Fig. 18.1 shows a force-extension graph for rubber.

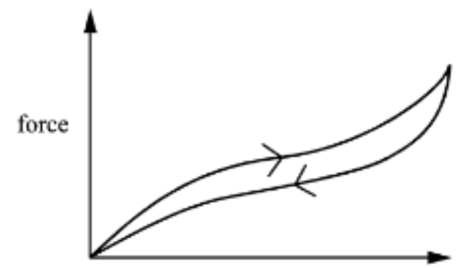

Fig. 18.1

Rubber is an ideal material for aeroplane tyres. Using the information provided, discuss the behaviour and properties of rubber and how its properties minimise the risks when aeroplanes land.

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Answer: i) Elastic: material returns to original dimensions when load is removed.

i) Plastic: material has permanent change of shape when load is removed.
ii) The material is elastic because the removal of force returns the rubber to its original length.
ii) The area under force-extension graph is work done.
ii) Repeated stretching and releasing the rubber warms up the rubber because not all the strain energy is returned back. The area enclosed represents the amount of thermal energy. During landing, some of the aeroplane's kinetic energy is transferred to thermal energy and therefore the aeroplane does not "bounce" during landing; hence this minimises the risk to passengers.

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